EXHIBIT 2

Expert Report of Durand R. Begault

July 8, 2024

AFC AUDIO FORENSIC CENTER
AUDIO • VIDEO • DIGITAL MEDIA

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RE: RULE 26 REPORT
Hicks v. City of Philadelphia, et al.
22-cv-00977-CMR
AFC 24-9002

MATERIALS EXAMINED

Q1: PDF document, Courtroom transcript November 7, 2002, "1 Hicks trial testimony.pdf"

Q2: PDF document, photographs from incident date, "D005464.pdf"

Q3: PDF document, deposition testimony, "1 Termaine Joseph Hicks 012624 MINI PDFA.pdf"

NE1: Begault, D. R. (2008). Forensic analysis of the audibility of female screams. Proceedings, Audio Engineering Society 33rd International Conference "Audio Forensics-Theory and Practice".

NE2: Sneddon, M., Pearsons, K. and Fidell, S. (2003). Laboratory study of the noticeability and annoyance of low signal-to-noise ratio sounds. Noise Control Engineering Journal, 51(5), p. 300-305.

NE3: Fidell, S. (1978). Effectiveness of Audible Warning Signals for Emergency Vehicles. Human Factors, 20(1), p. 19-26.

NE4: U.S. Department of Transportation (2021). Aviation Environmental Design Tool (AEDT) Technical Manual v. 3d. Report DOT-VNTSC-FAA-21-06.

* * *

Dear Counsel:

I was engaged by counsel during March–June 2024 to analyze audibility of human scream sounds, with reference to the courtroom testimony of Mr. Joseph Hicks on November 7, 2002 and deposition testimony on January 26, 2024.

Qualifications

I am the director of Audio Forensic Center, a wholly owned subsidiary of Charles M. Salter Associates that provides expert services in the areas of audio, video, acoustics and multimedia. My expertise and publications encompass audio-video media authentication, voice identification, enhancement of audio-video media, audibility of speech and warning signals, recorded gunshot analysis, and forensic musicology.

For over 30 years I have conducted analyses and testified as an expert in cases for attorneys, law enforcement agencies, and corporate internal investigations. I have qualified as an expert in numerous State and U.S. Federal Courts; the United States International Trade Commission (USITC); and courts in Canada and international arbitration panels. I have over 100 publications in acoustics, psychoacoustics and forensic audio-video, and have testified over 98 times in court or deposition. I have served as an adjunct faculty member of the Sound Recording Department at McGill University in Montreal, Canada, and have received a Fellowship Award from the Audio Engineering Society. I have also served on numerous journal review boards, technical committees and Ph.D. dissertation committees in acoustics, audio-video forensics, and multimedia engineering. Attached hereto and incorporated by reference as Exhibit **A** is a true and correct copy of my CV.

Summary

On April 9, 2024, I conducted audibility measurements in Philadelphia at three locations indicated by Mr. Hicks in his testimony (**Q1**), using calibrated acoustical measurement equipment. The time of day was from 5:00 -5:20 am, corresponding to the time of the incident. Sound level measurements were made using a loudspeaker playing a recording of a police siren, used as a "proxy" to represent the scream of the victim. The loudspeaker was located (1) facing upwards in a passageway next to a loading dock for St. Agnes' Hospital, corresponding to where the victim and Mr. Hicks were found; and (2) ~100 feet south of this location, on 15th Street between Mifflin Street and McKean Street, corresponding to an estimated location where the victim was first accosted.

The data indicates that for all measurements, a female scream would not be loud enough to be noticeable, and in most cases was not even detectable, under ideal listening conditions. I have produced audio recordings as exhibits to this report from these measurements and have conducted calculations of that data based on the literature. Under real-world, non-ideal conditions, the ability to both localize and identify a scream in an urban environment is impacted by background noise, building reflections, and acoustic obstructions.

Testimony of Mr. Hicks regarding locations where screaming was audible

Courtroom testimony by Mr. Hicks (**Q1**) pertinent to a claim of audibility of screaming is summarized below. Figure 1 shows a map of three receiver locations, R1, R2 and R3, to represent the location indicated by Mr. Hicks in his testimony; Figure 2 shows photographs.

*Receiver location 1 (**R1**).* "Well, after I left the store, I was walking down Snyder when I heard a scream. I didn't pay any attention to the scream. I didn't know where it came from, and I really didn't care, but I heard a scream. Now, as I was approaching 15th street, 15th and Snyder, I head another scream." (p. 24, lines 11-18).

*Receiver location 2 (**R2**).* "Well, I was maybe five feet from the corner, from 15th and Snyder, when I heard another scream that was louder than the previous ones." (p. 28, lines 6-9).

*Receiver location 3 (**R3**).* **Q:** "So, you were crossing the street. You see the person, and you stop because you heard the scream, and it was louder than it was when you first heard it at 15th or between 16th and 15th, right? **A:** No, I was all the way across. I was past the corner. I was closer to my apartment than 15th Street when I heard that last scream. Then, I had back-tracked. I didn't just stop in the middle of the street."

The deposition testimony of Mr. Hicks (**Q3**) indicated that the screams were "intermittent" and not "continuous" (p. 296, lines 5-16: **A:** "I wasn't—I mean, I don't believe it was ever a continuous scream, all right? So--. **Q:** All right. **A:** Did she stop screaming? It wasn't continuous. **Q:** Got you. It was intermittent? Would that be a way to describe it? **A:** That would be an accurate way to describe it, sure."

FIGURE 1. Receiver locations R1, R2, R3, and source locations S1, S2.

Measurement locations

To measure scream audibility**,** calibrated acoustical measurement equipment was used to make digital recordings for subsequent analysis in the laboratory. Two locations were identified for generation of a scream signal: (1) **S1:** The passageway at 1900 South 15th Street (identified as **S1** in Figure 1); and (2) **S2:** ~100 feet south of this location, on 15th Street between Mifflin Street and McKean Street, corresponding to an estimated location where the victim was first accosted (identified as **S2** in Figure 1). Measurements of the ambient noise in the receiver locations were also conducted.

Six recording were made (attached to this report as exhibits **X1-X6**) for analysis: three recordings from the passageway where the victim and Mr. Hicks were found:

(1) **S1** to **R1** (exhibit **X1**)
(2) **S1** to **R2** (exhibit **X2**)
(3) **S1** to **R3** (exhibit **X3**)

And three recordings from midway along 15th street, with the loudspeaker oriented as indicated:

(4) **S2** to **R1** (exhibit **X4**); loudspeaker oriented south.
(5) **S2** to **R1** (exhibit **X5**); loudspeaker oriented east, towards St. Agnes' Hospital
(6) **S2** to **R1** (exhibit **X6**); loudspeaker oriented north.

Source location and orientation of the loudspeaker for **S2** are estimates of when the victim was initially accosted, which would have corresponded to the first location **R1** where Mr. Hicks testified he heard a scream. The actual orientation is unknown.

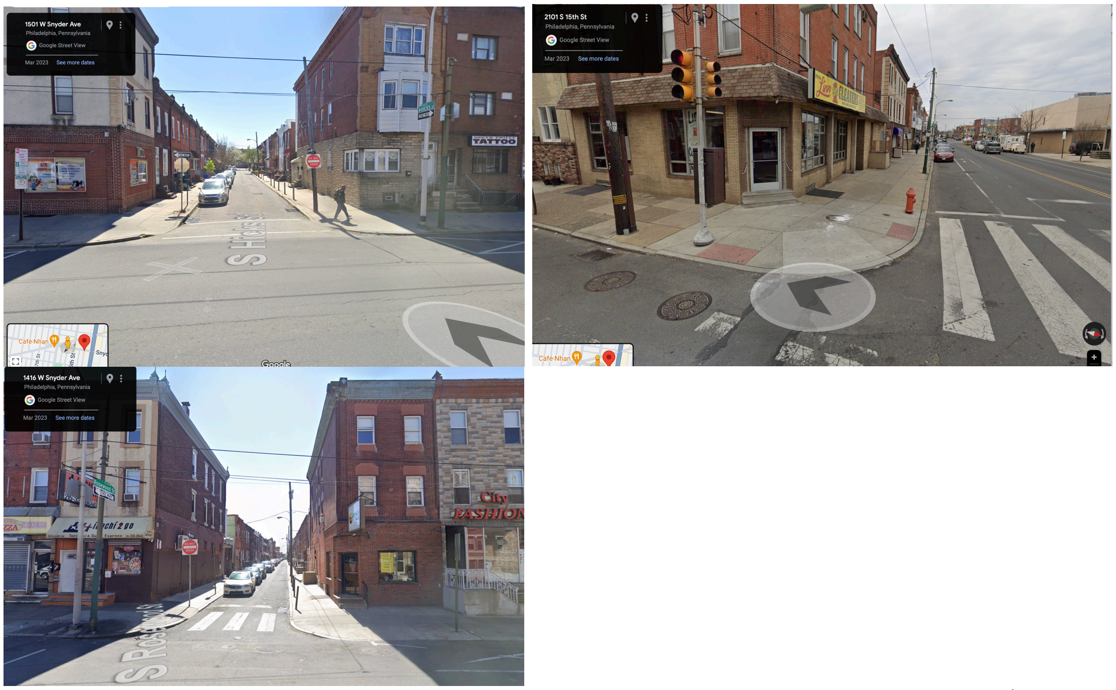

FIGURE 2. Receiver locations (clockwise from upper left): Hicks and Snyder **R1**; 15th and Snyder **R2**; Rosewood and Snyder **R3.**

FIGURE 3. Source locations. Left: **S1** (with 2001 photo from **Q2**); Right: **S2,** 15th street location (yellow arrow showing approximate loudspeaker location; red dashed arrow showing path to **S1**).

The time of day of the measurements was from 5:00–5:20 am, corresponding to the time of the incident. The weather was clear with minimal windspeeds.

Signal used to represent a female scream

Reference **NE1** provides laboratory measurements of female screaming from ten exemplar subjects at a distance of 3 feet. The average level of a scream starts at 107 decibels, falling to 102 decibels or less midway through the scream, due to a reduction in vocal power during exhalation. The victim was 39 years old at the time of the incident; the range of subjects in reference **NE1** was mid-20s to mid-40s, with the highest levels for persons under 30 years of age.

It was impractical to use actual recordings of screaming for the tests. A recording of a police siren in wail mode was used as a proxy signal, at three different successive levels, corresponding to the average scream level reported in **NE1**: 107, 102 and 95 decibels, to simulate the reduction in a human scream level over time. The siren has its primary energy in frequencies similar to a typical scream, around 1.5 kHz. See Figure 4.

A primary difference from a scream is that the siren maintains a constant level (unless is it adjusted in steps, as done here) whereas a scream gets *progressively* quieter. Another difference is that a police siren is *unvarying* in its character, whereas there can be significant differences within or between different scream sounds from one person, or between different persons. Finally, the loudspeaker remained in a fixed position during each test, whereas a victim would be moving. The use of a siren signal would therefore maximize audibility observed in the measurements, compared to an actual scream.

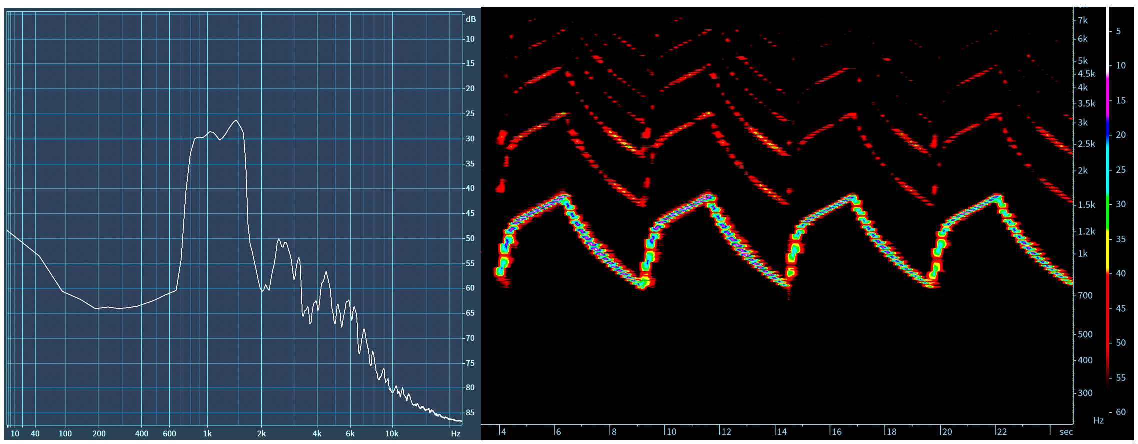

FIGURE 4. Left: Average frequency content of a siren wail (maximal energy between ~700-1.6 kHz). Frequency on the *x* axis, level on the *y* axis. Right: Spectrogram of a wail siren showing the characteristic rise and fall in frequency. Time on the *x* axis, frequency on the *y* axis, level shown by color intensity.

Calculation of audibility and noticeability

The concept of *audibility* refers to the ability to *detect* the presence of a signal with a level of statistical reliability. It is typically measured under laboratory conditions, such as in an audiometric hearing test. Subjects in audibility tests are "primed" to listen attentively for a signal in controlled experiments.

The concept of *noticeability* is described as "the level of detectability of an acoustic signal that reliably attracts the attention of someone engaged in an activity other than specifically listening for such a sound", or a level that would "command prompt attention" (**NE2**). Compared to the level necessary for detection, a higher level of sound is needed to reach a statistically defined chance of *noticing* a signal. The literature has applied the concept of noticeability to areas such as warning signal and siren audibility, and aircraft noise disturbance (ref. **NE2**-**NE4**).

References **NE2**-**NE4** include calculation methods for including the level of background ambient noise to calculate the likelihood of noticeability of a signal, using a metric called D'L ("d-prime level"). If there is sufficient signal level relative to noise in a recording of a signal, D'L can be calculated from the 1/3 octave band spectra measurements of the signal and noise. Essentially, a signal is considered to be noticeable 80-95% of the time when D'L is equal to 16-30 (roughly, a signal that is 8-22 decibels higher in level than background noise).

The ambient level during the measurements ranged from ~47–63 decibels, depending on traffic on nearby roads, or people talking in the vicinity of the recording. Exhibits **X7 -X9** are audio recording segments of the ambient background noise without a siren signal under these ambient conditions. Noticeability analyses were made using the *minimal* background noise condition in exhibit **X7**. (Noticeability and detection would have been impacted more had the analyses used the louder background noise of exhibit **X8** or **X9**).

Table I shows the results of the analyses. Listening to exhibits **X1-X6** at a calibrated level shows that the siren is *undetectable* or *barely detectable* in five of the six tests conducted. The two "barely detectable" and the one "detectable" tests would require a listener to be "primed" to actively listen for a recognizable emergency vehicle siren signal.

None of the six tests yielded a level that would be objectively sufficient to be considered *noticeable* (D'L > 16). Measurement S2 to R1 (exhibit **X4**) had the highest signal level, since the fixed position loudspeaker was aimed directly down 15th Street to the receiver position; nevertheless, the signal level would not be considered sufficient to "command attention" per **NE2-NE3**. For the noticeability calculations marked N/A in Table I, the signal was too low to distinguish it from the background noise or was completely absent.

All tests represent "best case" scenarios for detection or noticeability of a scream, because:

- A siren has a more consistent level over time than a scream. Mr. Hicks testified that the screams he heard were intermittent and not continuous (**Q3**).

- A siren is a more consistent, easily recognizable signal than a scream.

- The siren was reproduced with a loudspeaker in a fixed position, optimizing the transmission of the signal. In the actual event, the victim would have been in motion as they were moved from the area of **S2** to the passageway at **S1.**

- Had calculations or recordings been made with louder background noise, e.g., exhibit **X8–X9**'s traffic noise or talking, the likelihood of detection and noticeability would have been further reduced or impossible.

For a walking "casual" listener who is not "primed" to be attentive to the presence of a scream, the likelihood of hearing a scream from the vicinity of position **S2** is highly unlikely; the the likelihood of hearing a scream from **S1** is extremely unlikely or impossible.

TABLE I.

Test	Listening test	Noticeability calculation D'L
S1 to **R1** (exhibit **X1**)	undetectable	N/A
S1 to **R2** (exhibit **X2**)	barely detectable	N/A
S1 to **R3** (exhibit **X3**)	undetectable	N/A
S2 to **R1** (exhibit **X4**); Loudspeaker oriented south	Detectable (not noticeable)	13.1
S2 to **R1** (exhibit **X5**); Loudspeaker oriented east	barely detectable	N/A
S2 to **R1** (exhibit **X6**); Loudspeaker oriented south	undetectable	N/A

The presence of buildings, the passageway walls and other acoustical obstructions between a scream sound source and a receiver walking on Snyder Avenue impacts both the level of the sound, and the ability to *localize* the origin of the sound. Figure 1 shows the presence of multiple buildings between the source and receiver positions, with the distance between the source and the receiver 860 feet or greater during the tests. Figure 3 (left) shows the walls and buildings surrounding the passageway walls.

Human sound localization uses differences of level and timing at the two ears to determine direction and uses level to determine distance. The transmission of a sound in urban environments over long distances means that a wavefront reaches a listener mostly or completely by indirect paths (reflections and diffraction), which affects the level and timing differences normally used by a listener for localization when a direct path of sound is present. (The difficulty in localizing sirens from moving emergency vehicles is a condition present in urban driving). Acoustical obstructions and background sounds similar to human screaming (e.g., brake squeals, shouting) can also impact the ability to make reliable *identification* of a scream. Finally, a signal that is intermittent and not continuous will be more difficult to localize and identify a sound, compared to a sound that is continuous.

* * *

These analyses are provided with a high degree of scientific certainty. I reserve the right to modify my opinions as additional information becomes available to me.

Sincerely,

AUDIO FORENSIC CENTER

Durand R. Begault Ph.D.
Director

ATTACHMENTS: -Audio wave file exhibits **X1-X10**

APPENDIX A. DETECTION AND NOTICEABILITY CALCULATIONS

(From **NE2**)

Detectability (d′) is the ability to detect a signal in the presence of noise, quantified by the bandwidth adjusted signal-to-noise ratio:

$$d' = \eta\sqrt{\sum_{i=1}^{N}\Delta f_i\left(\frac{s_i}{n_i}\right)^4}$$

where

| *N* is the efficiency of a human detector (assumed to be 0.4 for a human observer);
⊗f_i is the bandwidth of the i_{th} one-third octave band;
s_i is the sound pressure of the signal in the i_{th} one-third octave band;
n_i is the sound pressure of the noise in the i_{th} one-third octave band.
Detectability Level (D′L) is the decibel equivalent value of d′, or 10 log d′
.

Noticeability is the ability of an audible signal to attract the attention of an individual engaged in an activity other than listening for such a sound. A detectability level of D’L =>16 is a sound level that would be noticeable (**NE2-NE3**).

On the recordings, only exhibit **X4** had an audible siren signal detectable under laboratory conditions that qualified for the one-third-octave band analysis for the D’L noticeability calculations.

X4 noticeability calculation D’L = 13.1:

					SIGNAL		NOISE							
ANSI Band #	Freq. (Hz)	Bandwidth	Efficiency (η)	10*log(η)	SPL_{signal}	$Alog(SPC_S)$	SPL_{noise}	$Alog(SPC_N)$	ΔSPL	$D'L_{band}$	$D'L_{band}$	EASN Thld.	d'_{band}	$(d'_{band})^2$
17	50	11	0.4	-6.96		1.00E+00	52.6	1.84E+05	-52.6	-51.4	-54.4	40.2	0.0	0.0
18	63	15	0.4	-6.26		1.00E+00	54.0	2.51E+05	-54.0	-52.1	-54.4	35.0	0.0	0.0
19	80	19	0.4	-5.56		1.00E+00	52.9	1.95E+05	-52.9	-50.5	-52.1	29.8	0.0	0.0
20	100	22	0.4	-5.06		1.00E+00	52.2	1.65E+05	-52.2	-49.4	-50.5	25.8	0.0	0.0
21	125	28	0.4	-4.66		1.00E+00	50.7	1.17E+05	-50.7	-47.4	-48.1	22.2	0.0	0.0
22	160	40	0.4	-4.36		1.00E+00	46.3	4.27E+04	-46.3	-42.3	-42.7	19.0	0.0	0.0
23	200	44	0.4	-4.16		1.00E+00	45.3	3.36E+04	-45.3	-41.0	-41.2	16.2	0.0	0.0
24	250	56	0.4	-3.96		1.00E+00	43.0	1.99E+04	-43.0	-38.2	-38.2	13.4	0.0	0.0
25	315	75	0.4	-3.76		1.00E+00	41.3	1.35E+04	-41.3	-35.9	-35.7	11.6	0.0	0.0
26	400	95	0.4	-3.56		1.00E+00	40.4	1.10E+04	-40.4	-34.5	-34.1	9.3	0.0	0.0
27	500	110	0.4	-3.56	39.5	8.98E+03	39.8	9.51E+03	-0.2	6.0	6.4	7.8	4.0	15.7
28	630	150	0.4	-3.56	39.0	8.03E+03	39.5	8.86E+03	-0.4	6.5	6.9	6.3	4.4	19.7
29	800	190	0.4	-3.56	39.7	9.32E+03	38.7	7.45E+03	1.0	8.4	8.8	6.3	6.9	47.5
30	1000	220	0.4	-3.56	40.0	9.93E+03	38.3	6.76E+03	1.7	9.4	9.8	6.3	8.7	75.8
31	1250	280	0.4	-3.76	37.7	5.94E+03	35.9	3.91E+03	1.8	10.1	10.3	6.1	10.2	103.4
32	1600	400	0.4	-3.96	34.7	2.98E+03	33.8	2.40E+03	0.9	10.0	10.0	5.4	10.0	99.1
33	2000	440	0.4	-4.16	28.6	7.30E+02	31.8	1.51E+03	-3.1	6.1	5.9	5.2	4.1	16.5
34	2500	560	0.4	-4.36	27.7	5.84E+02	30.0	1.00E+03	-2.3	7.4	7.0	4.0	5.5	30.5
35	3150	750	0.4	-4.56		1.00E+00	28.9	7.83E+02	-28.9	-18.5	-19.1	2.8	0.0	0.0
36	4000	950	0.4	-4.96		1.00E+00	25.9	3.93E+02	-25.9	-15.0	-16.0	2.4	0.0	0.0
37	5000	1100	0.4	-5.36		1.00E+00	23.2	2.09E+02	-23.2	-12.0	-13.4	4.0	0.1	0.0
38	6300	1500	0.4	-5.76		1.00E+00	21.2	1.32E+02	-21.2	-9.3	-11.1	8.1	0.1	0.0
39	8000	1900	0.4	-6.26		1.00E+00	20.9	1.22E+02	-20.9	-8.4	-10.7	13.1	0.1	0.0
40	10000	2200	0.4	-6.86		1.00E+00	20.3	1.07E+02	-20.3	-7.6	-10.5	17.0	0.2	0.0
				"DBA"	**48.5**		**47.5**		**0.999132**				$\Sigma(d'_{band})^2$	**408.2**
													d'_{total}	20.2
													$D'L_{total}$	**13.1**

APPENDIX B: INSTRUMENTATION, SOFTWARE

- Mackie GRM350 loudspeaker
- Bruel and Kjaer 2230 Type 1 sound level meter; 2133 real time frequency analyzer
- NTI Audio MR-PRO audio generator, XL2 Type 1 sound level meter
- Rion DA-20 four channel data recorder
- Mathworks Matlab; Adobe Audition

APPENDIX C: AUDIO FILE EXHIBITS

Exhibit X1-X6: Measurements of siren signal. Refer to Table I for the measurement and sound source positions.

Exhibit X7: Ambient background sound, no siren signal, ~5:05am April 9, 2024, from position R1.

Exhibit X8: Ambient background sound, with nearby talking bystander and truck pass-by.

Exhibit X9: Ambient background sound, with traffic pass-by, from position R3.

Exhibit X10: Calibration tone, 94 dB 1 kHz, from instrumentation. The tone is 30 decibels low relative to exhibits **X1-X9**, which were amplified by 30 decibels for use as demonstrative exhibits.

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